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Tailored Collaboration

DORIS—Energy Consumption Calculator for Seawater Reverse Osmosis Systems

User Manual

Report #4446

Subject Area: Water Resources and Environmental Sustainability

DORIS—Energy Consumption Calculator for Seawater Reverse Osmosis Systems

User Manual

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Published by:

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FOREWORD

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This publication is a result of a research project fully funded or funded in part by WRF subscribers. WRF's subscription program provides a cost-effective and collaborative method for funding research in the public interest. The research investment that underpins this report will intrinsically increase in value as the findings are applied in communities throughout the world. WRF research projects are managed closely from their inception to the final report by the staff and a large cadre of volunteers who willingly contribute their time and expertise. WRF provides planning, management, and technical oversight and awards contracts to other institutions such as water utilities, universities, and engineering firms to conduct the research.

A broad spectrum of water supply issues is addressed by WRF's research agenda, including resources, treatment and operations, distribution and storage, water quality and analysis, toxicology, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers to provide a reliable supply of safe and affordable drinking water to consumers. The true benefits of WRF's research are realized when the results are implemented at the utility level. WRF's staff and Board of Trustees are pleased to offer this publication as a contribution toward that end.

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ACKNOWLEDGMENTS

SPI would like to thank:

- Water Research Foundation, for funding, input and guidance on project development and testing the software: Jennifer Warner, research manager; Shahid Chaudhry, Maribel Medina, and Tom Seacord, WRF Project Advisory Committee members;
- West Basin Municipal Water District, for co-funding the project and making the Ocean Water Desalination Demonstration Facility (OWDDF) at Redondo Beach available for data gathering used in the guidance of the software;
- United Water, for conducting the operations at the West Basin OWDDF and providing operating and water quality data.

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1. About Doris

Energy consumption in seawater reverse osmosis (RO) treatment systems, while a major component of the O&M costs, often suffers from a lack of standardization in the calculation methodology, format and transparency. Energy consumption is often presented for narrow aspects of the overall project (e.g. excluding intake, a second pass RO etc.). Moreover, values are often presented only on the RO desalination process at ideal conditions (new membrane, no fouling, etc.).

The nature of the design of desalination treatment and product delivery calls for the calculation of energy consumption for all segments of a plant. There is a need in the desalination industry for completeness and continuity in how energy consumption is calculated and presented. As such, this application is a thorough tool which can be used in calculating all components of the energy consumption employed in a seawater RO treatment system, from intake to pretreatment, first pass RO, second pass RO, post-treatment and distribution system.

The versatility of the application, through its user friendly interface, extensive built in default numbers and thorough guidance makes it usable in many branches of the industry, from planners to municipal agencies, design engineers and operators. It represents the results of a twelve month Tailored Collaboration between Water Research Foundation (WRF) and West Basin Municipal Water District (West Basin); SPI was the selected contractor and principal investigator for the project.

2. Computer Requirements and Installation

- Minimum System Requirements

Windows

- Windows 8 (Desktop)
- Windows 7
- Windows Vista SP2
- Windows Server 2008
- Windows Server 2012 (64-bit)
- RAM: 512MB; Disk space: 124 MB
- Administrator privileges for installation

Linux

- Oracle Linux 5.5+
- Oracle Linux 6.x (32-bit)*, 6.x (64-bit)**
- Red Hat Enterprise Linux 5.5+, 6.x (32-bit)*, 6.x (64-bit)**
- Ubuntu Linux* 10.04 and above
- Suse Linux Enterprise Server* 10 SP2, 11.x
- RAM: 512 MB; Disk space: 128 MB
- Administrator privileges for installation

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*Not certified on Oracle VM
**Not certified on Oracle VM. Only 64-bit JVM is certified.

- Recommended Hardware Requirements:
  - 1.5 GHz Processor
  - 1 GB RAM
  - 200 MB free disk space

- Software Requirements:
  - Java SE Runtime Environment 7u45 (or later versions) available here: http://oracle.com/technetwork/java/javase/downloads/jre7-downloads-1880261.html

- Distribution:
  - The application is delivered in a .zip file containing the jar file.

- Running the application:

There are two options for running the application:
- Double click on Doris.jar from the zip distribution
- Manually run from command line: java -jar <jar-location> where <jar-location> represents the full path to the jar file.

3. Getting Started

- Double click on the Executable Jar file named "Doris.jar" in order to launch the application
- Click "Continue" on the acknowledgement screen
- Click File, then select from the following three (3) options:

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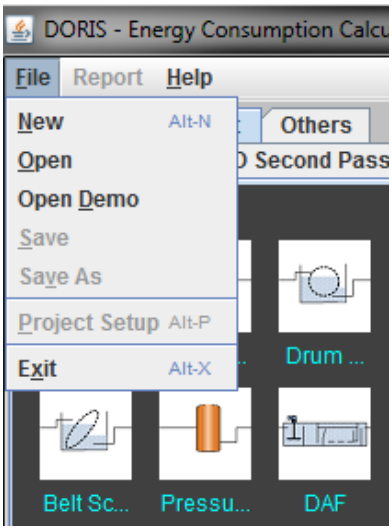
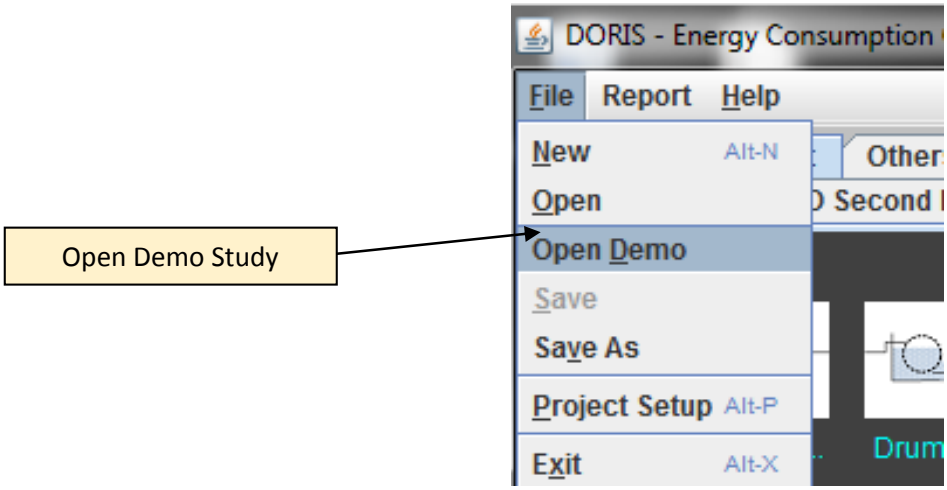
- Select “New” to start a new study
- Select “Open” to open an existing study saved previously
- Select “Open Demo” to open the demonstration study provided with the application



4. Opening Demo and Existing Files

A demonstration study was provided with the application to facilitate learning and present a typical case of a SWRO treatment system. To open the Demo file, click File → Open Demo. Changes can be made to the Demo file, however it is recommended to save the changed file under a different name such that Demo file is preserved as reference.



To open on exiting, previously saved file, click File → Open then select the file from the location previously saved at.

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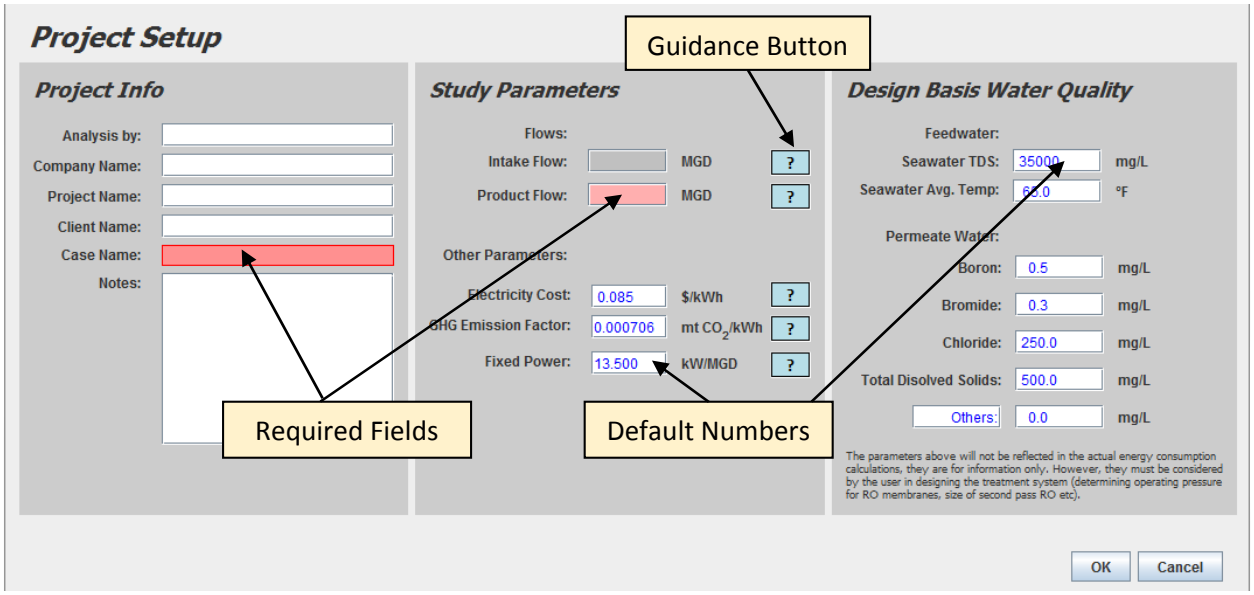
5. Opening a New Study

If a new study is selected from File menu, Project Setup screen will open. The screen is divided in three segments:

- Project Info;
- Study Parameters – values from these fields will be used in calculations;
- Design Basis Water Quality – values from these fields are not reflected in the actual energy consumption however they must be considered by the user in designing the treatment system. An exception is the Seawater TDS which is used in calculating the specific gravity of seawater and RO concentrate.

The required fields are marked in red. For example, Case Name is a required field and a name for the new study must be entered. Either an Intake Flow or a Product Flow are also required (not both!). The blue numbers are default numbers, which can be modified by the user. Guidance buttons are provided throughout the application; when clicked on, additional information for corresponding fields is displayed.



Once information is entered in Project Setup, a white working area marked by dotted blue lines becomes available on the right side of the screen while the left side contains the library of icons. Each icon in the library is a component available to be used for the treatment system to be designed in the working area. An icon can be moved from library to the desired spot in the working area by click-drag-drop the icon.

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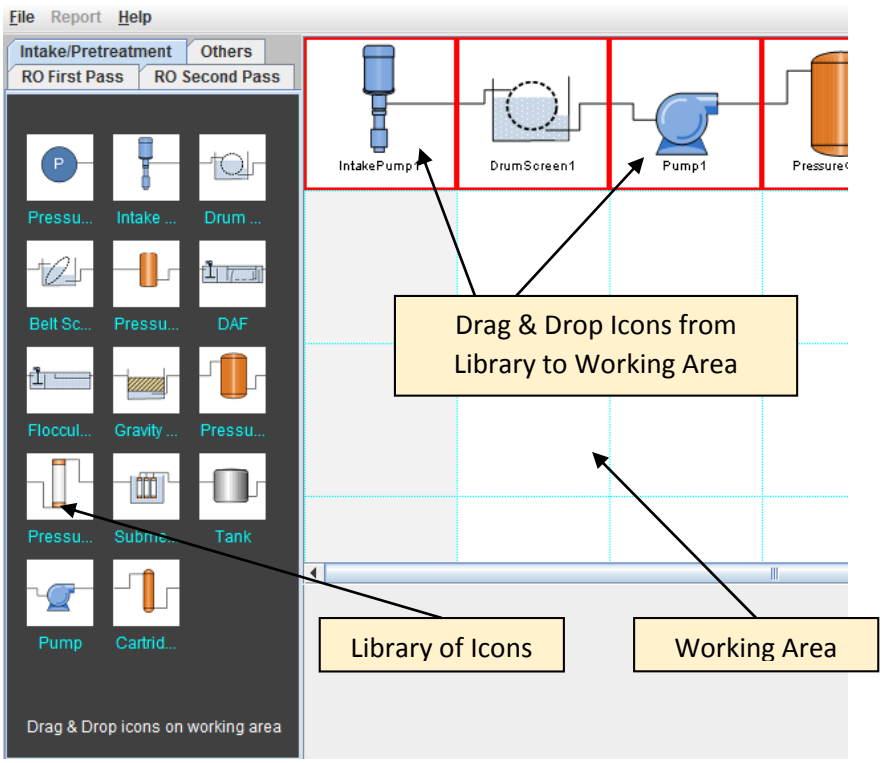
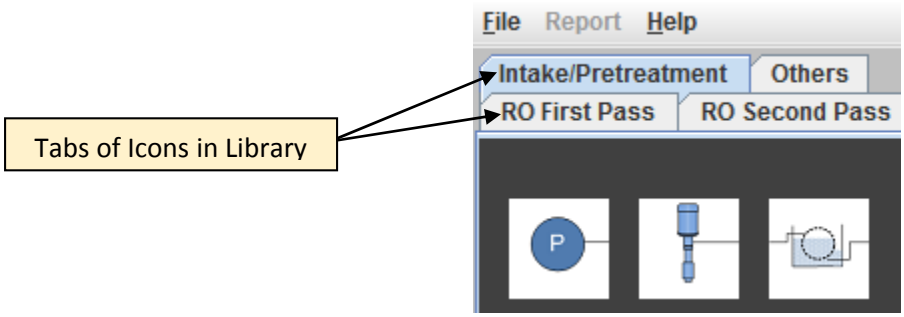


6. Library of Icons

The library of icons is divided in four tabs, corresponding to treatment areas typically used in a SWRO system. Click between tabs from Intake/Pretreatment to RO First Pass, RO Second Pass and Others to select the desired icons to working area.



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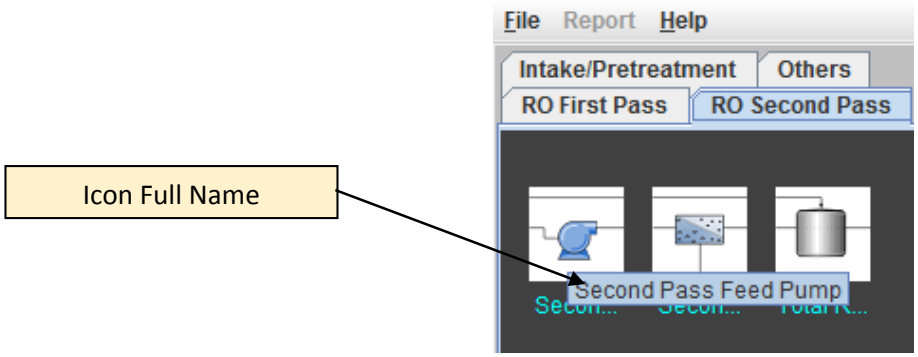
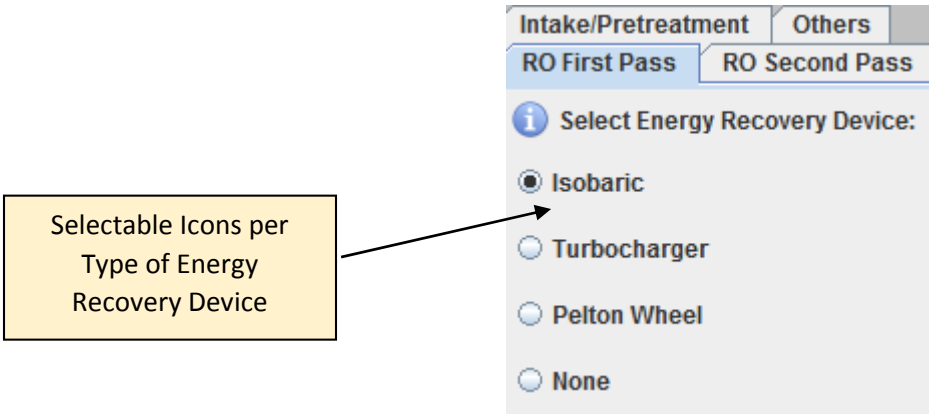
Features of the Library of Icons:

- Hover over an icon to see the full name of an icon:



- For ease of use, some icons are grouped in assemblies of more than one unit. The assemblies are:
  - In Intake/Pretreatment tab:
    - Submersible MF/UF Assembly
  - In RO First Pass tab:
    - Isobaric Assembly
    - Turbocharger Assembly
    - Pelton Wheel Assembly
    - No ERD Assembly
- RO First Pass tab is further divided in four sections selectable with radio buttons, based on type of energy recovery device to be used:



- In the RO First Pass tab, additional information to help selecting the right connecting spool and RO permeate tank is available by hovering with the mouse over each of the sub-categories of this tab:

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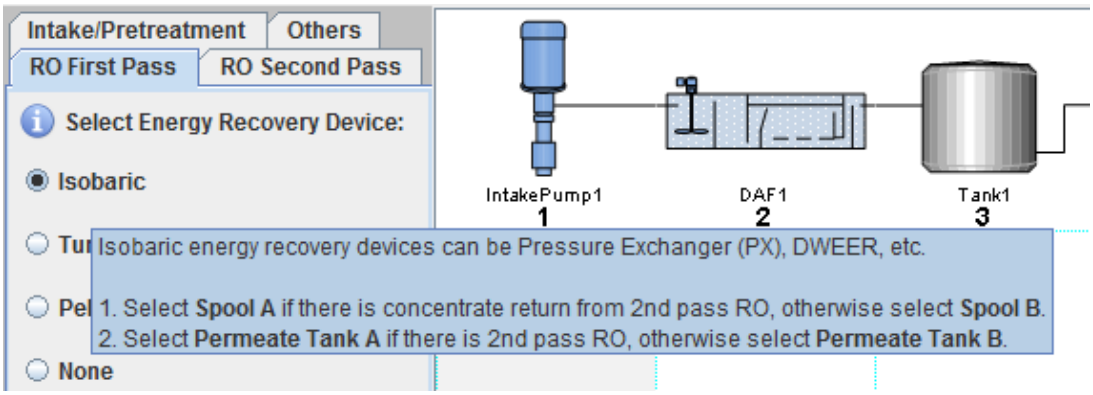
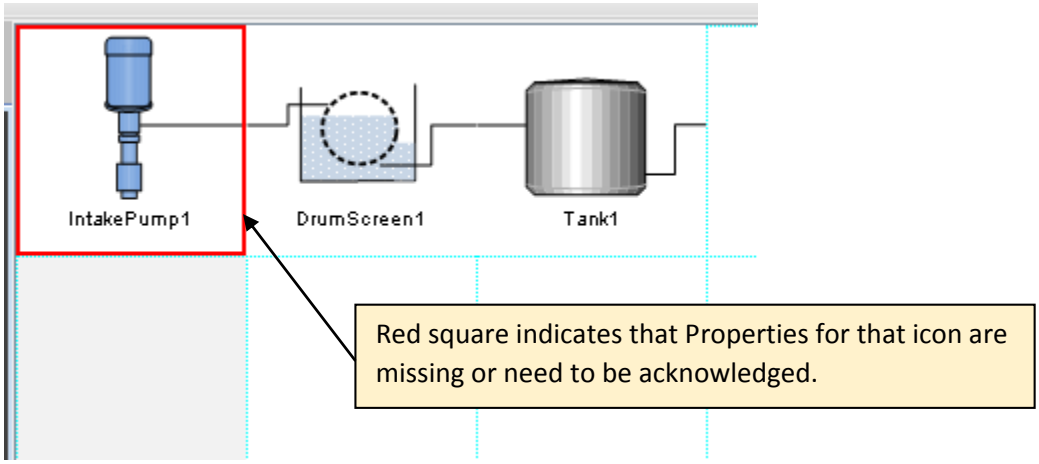


- **It is strongly recommended to not interchange icons designated for a certain area of the treatment system into another. For example, do not use icons from tab Intake/Pretreatment for First Pass RO.**

7. Property Windows for Icons

- When icons are first dropped in the working area, a red square is present around each icon. Double click or right click on an icon to open the Property Window. It is necessary that the Property Window for all icons placed in the working area is opened and the entries are either acknowledged (in the case of default numbers) or modified. Also, all fields highlighted in red must be filled. There are no default numbers provided for fields marked in red because they are study specifics;


IntakePump1
DrumScreen1
Tank1
Red square indicates that Properties for that icon are missing or need to be acknowledged.

- Default numbers are provided in blue; once changed by the user, they become black;
- The majority of fields are provided with a Guidance window, and there is a Help window for each icon or assembly;

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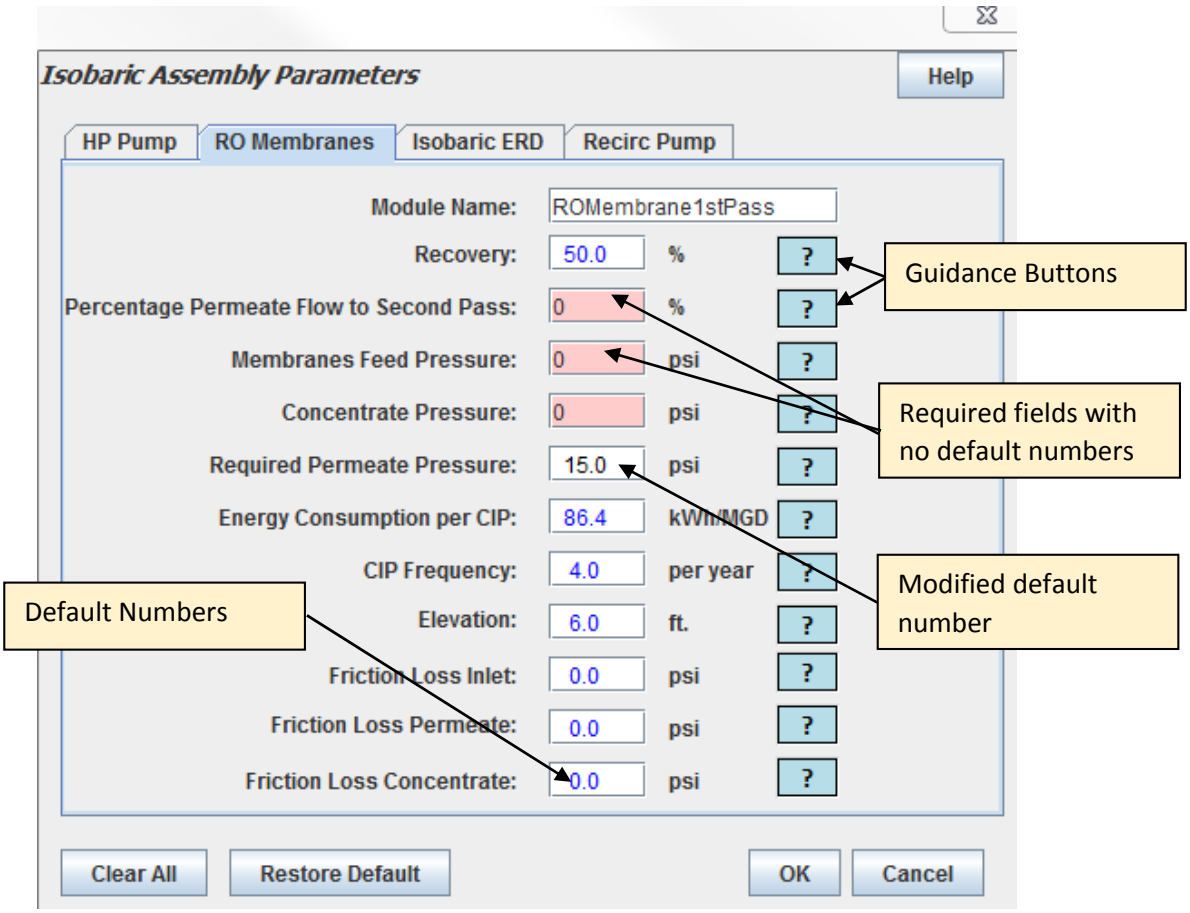

- Every Property window has a Clear All button which deletes existing entries and a Restore Default which re-populates the fields with default numbers.

8. Features of Working Area

- **Always start a study with either Intake Pump or Pressure Source**
- Icons and assemblies of icons are designed to snap on the marked blue squares on the working area;
- Grey squares on the right and left sides of the working area are reserved for connectors and are not available for placement of icons;
- Click and drag to move an icon;
- Right click on an icon to delete it;
- Working area is provided with scroll bars to navigate to right side of the screen, accommodating computers screens of various size and resolution;
- Calculate button is not available until all red squares around icons have disappeared;

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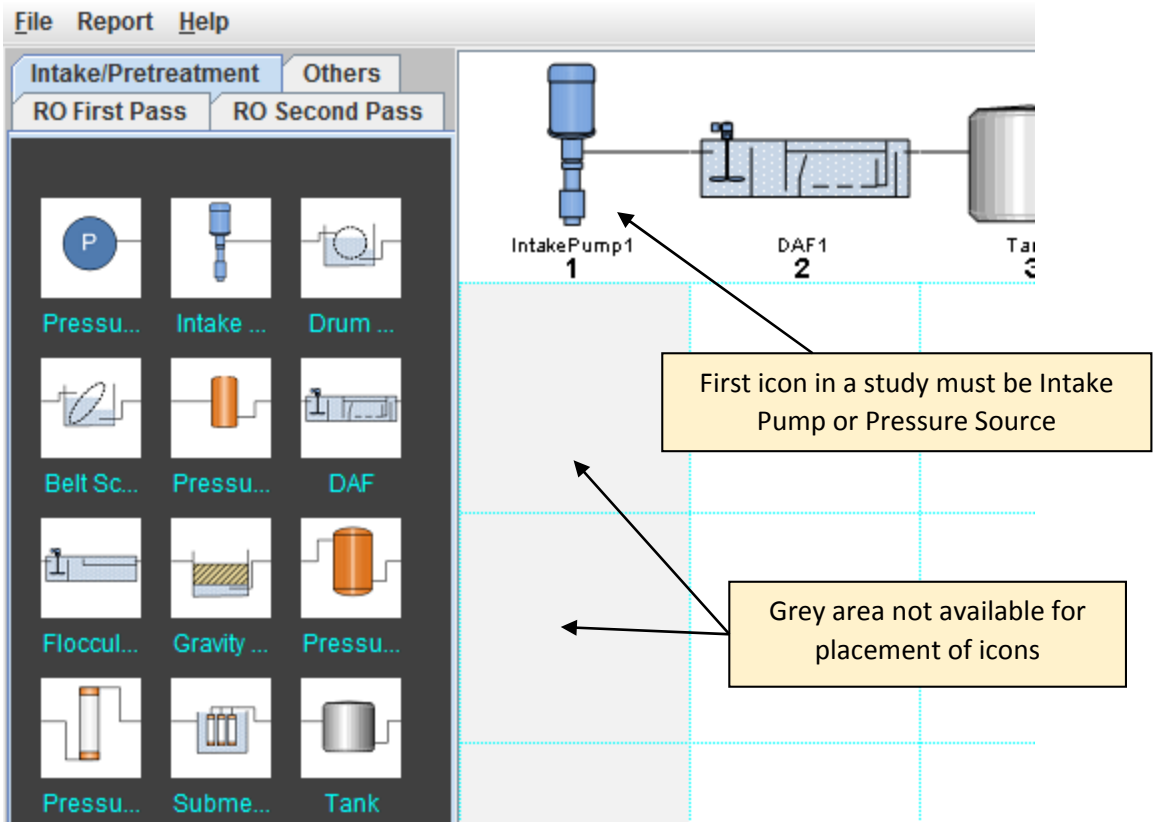
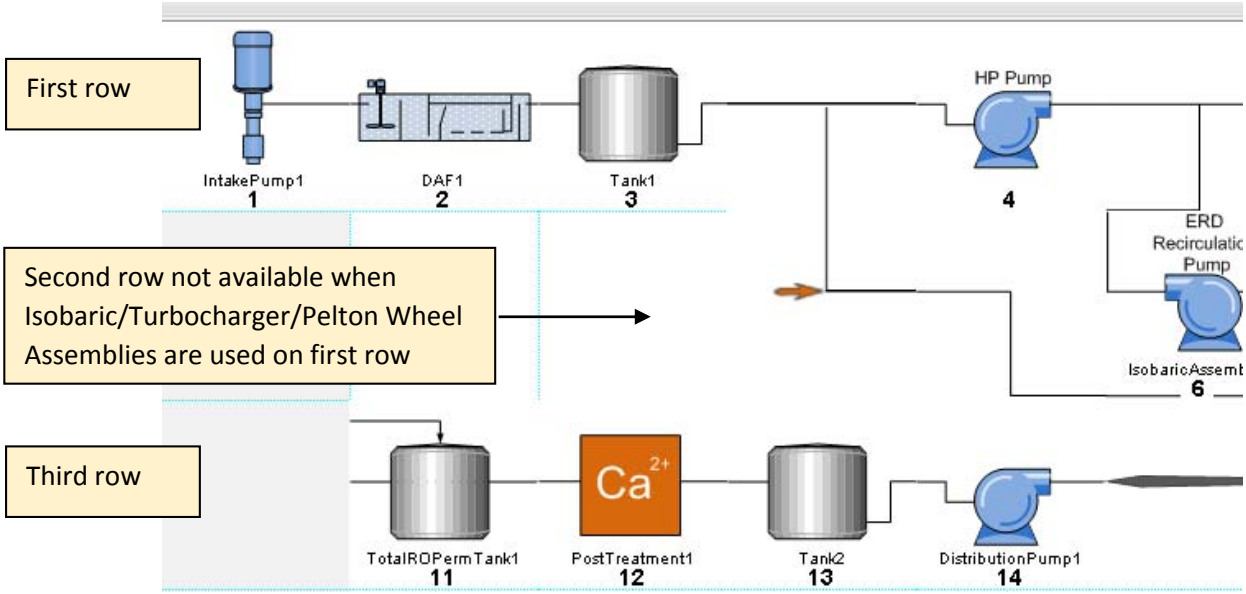


- When a row is completed with icons, continue on the next row. If an assembly (such as Isobaric, Turbocharger or Pelton Wheel) is present on the first row, the next available row is the third (not second).



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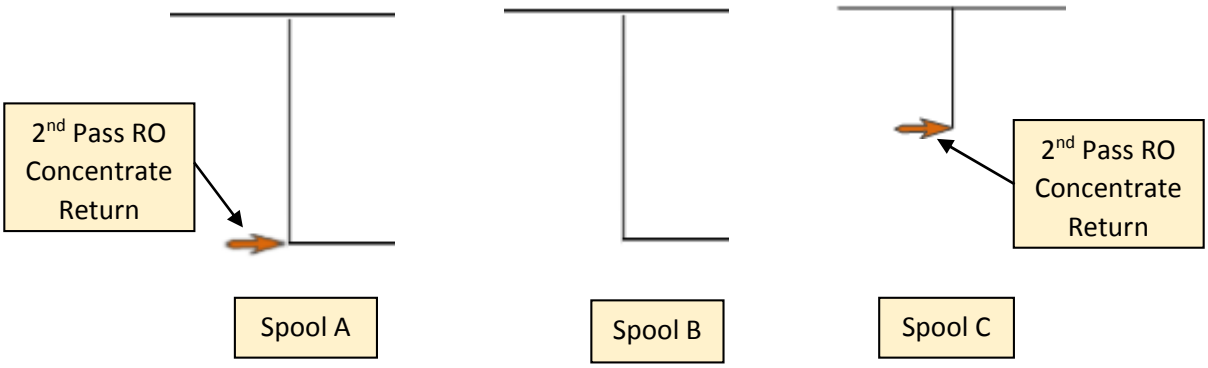
9. Selection of Icons for First Pass RO

Spools A, B and C:

- If Isobaric ERD is selected
    - Either Spool A or B must be used. They are required to divide the flow for the isobaric ERD design and provide options for RO concentrate return from Second Pass RO
    - Use Spool A if there is RO concentrate return from Second Pass RO
    - Use Spool B if there is no RO concentrate return from Second Pass RO (but still have a Second Pass RO)
    - There will be no difference in using Spool A or B if there is no Second Pass RO
    - Do not use more than one spool
    - Either Spool A or Spool B must be used
- If any of the other ERD options is selected:
    - Use Spool C if there is RO concentrate return from Second Pass RO
    - Do not use any spool if there is RO concentrate return from Second Pass RO



Tanks A and B:

- Two types of tanks are provided for the first pass RO permeate, Permeate Tank A and Permeate Tank B
    - Use Tank A if there is a Second Pass RO (total or partial)
    - Use Tank B if there is a Second Pass RO

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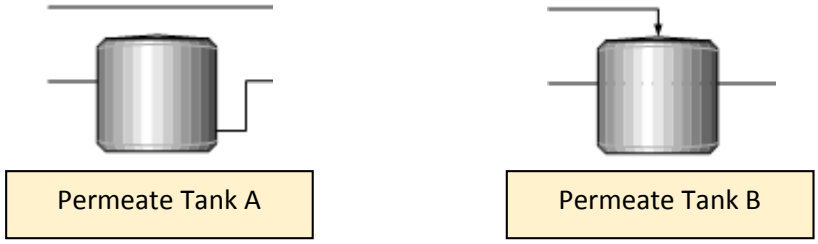
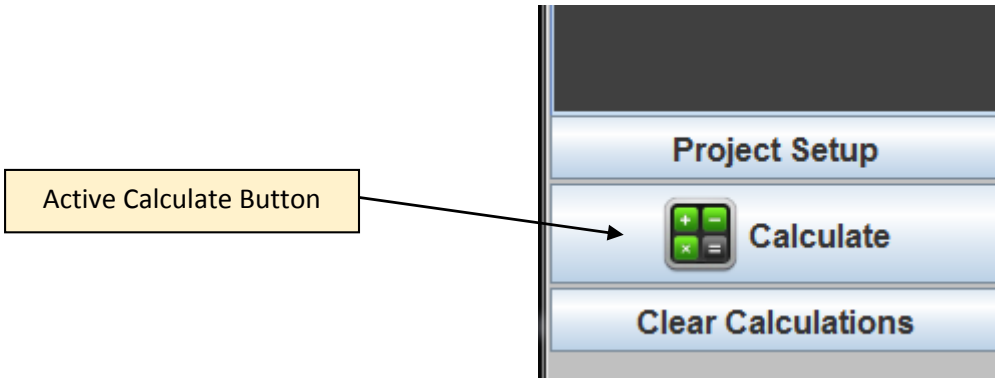
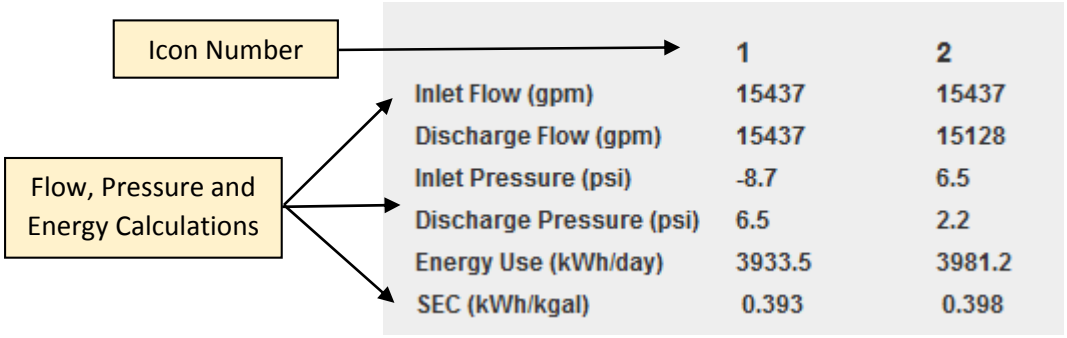


10. Calculations

- Once all icons are placed in the working area and there is no red square remained for any of the icons, Calculate buttons becomes available;



- Once Calculate button is clicked, each icon in the working area is assigned a number, connectors are inserted at end of rows and Table of Results is displayed under the working area. First line of the table contains the icons number then results are displayed on the following rows;



	1	2
Inlet Flow (gpm)	15437	15437
Discharge Flow (gpm)	15437	15128
Inlet Pressure (psi)	-8.7	6.5
Discharge Pressure (psi)	6.5	2.2
Energy Use (kWh/day)	3933.5	3981.2
SEC (kWh/kgal)	0.393	0.398

- There is no energy calculations for icons such as pressure source, spools, tanks, cartridge filters, and energy recovery devices (savings in energy are reflected in calculations for the high pressure pump for first pass RO);

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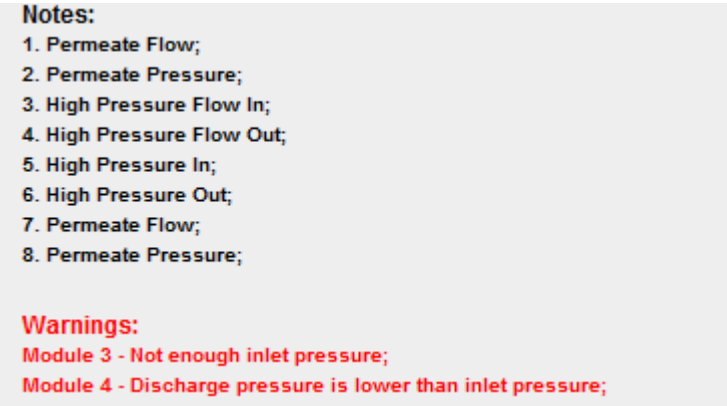
- Use the horizontal and vertical scroll bars to navigate through the table of results;
- Scroll down to the bottom of table to see Notes and Warnings (if applicable);


Notes:
1. Permeate Flow;
2. Permeate Pressure;
3. High Pressure Flow In;
4. High Pressure Flow Out;
5. High Pressure In;
6. High Pressure Out;
7. Permeate Flow;
8. Permeate Pressure;
Warnings:
Module 3 - Not enough inlet pressure;
Module 4 - Discharge pressure is lower than inlet pressure;

- After a change is made to property of an icon or an icon is moved, inserted or deleted, click Clear Calculation to reset the case study and click Calculate again.

11. Warnings

- A number of warnings have been designed in the application. The most significant ones are:
    - Not enough inlet pressure is provided to an icon. To address the issue:
        - A pump can be inserted immediately upstream
        - Elevation of the icon upstream can be increased or the elevation of current icon decreased
        - The required inlet pressure for the icon (if applicable) can be lowered, understanding the implications in design and equipment selection
    - A pump the inlet pressure is higher than the discharge pressure. This is an indication that the pump is not required and it can be eliminated. In such cases, no energy is calculated for the pump as it will result in negative values
- Note that calculations might not be correct if warnings are still present.

12. Reports

- Reports are available for viewing and printing by clicking Report and then select the type of report desired.

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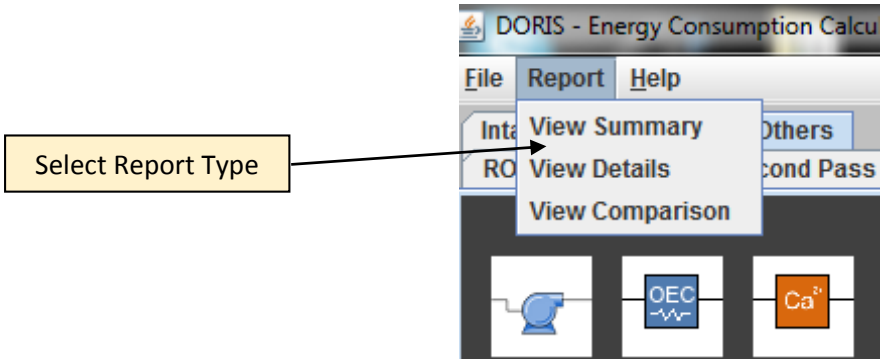

- Three report types are available:
    - Summary Report (three pages):
        - Summary of information entered in Project Setup (Water Quality for Feed and Permeate Water etc.)
        - Specific Energy Consumption (SEC) grouped by areas of treatment corresponding to the tabs in Library of Icons, with a graphical representation
        - Energy related costs and Greenhouse Gas Emission equivalence for the case study
        - Process diagram representing the icons selected with table of results
        - Warnings (if applicable)
    - Details Report
        - Summary report followed by details on entry fields and calculations for every icon present in the study
    - Comparison Report (one page):
        - Compares the summary results for two case study
- Navigation buttons, zoom in/out buttons, and scroll bars are provided to each page of a report. Reports can be printed entirely or on specific page.

13. Saving a File

- A new study can be saved using File →Save As at any stage once the required information on Project Setup is completed;
- An existing study can be saved by clicking File →Save or File →Save As to rename or save in a different location.

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